Measurement of the Particle Size Distribution of Powder by the Thermal Analysis of Reaction Velocity

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18. Measurement of the Particle Size Distribution of Powder by the Thermal Analysis of Reaction Velocity.

Eiji Suito, Nishio Hirai and *Koiji Taki.*

The particle size distribution of the powder is obtained by measuring the reaction velocity, for instance, dissolving reaction of the powder. Now we assume a system of n particles with radius r, the mass of a particle m, total mass M, the surface area of a particle s and total surface area S, then

$$M=nm=\frac{3}{4}\pi n\rho r^3 \quad (\rho:\ \text{density}) \tag{1}$$

$$S=ns=4\pi nr^2 \tag{2}$$

$$S=an^{1/3}M^{2/3},\quad a=4\pi\left(\frac{3}{4}\pi\rho\right)^{-2/3} \tag{3}$$

As the reaction velocity is proportional to the surface area and the concentration $[C]$ of the solution of reactant,

$$-\frac{dM}{dt}=k'S\,[C] \tag{4}$$

Under the condition of $[C]=$const.,

$$-\frac{dM}{dt}=kn^{1/3}M^{2/3} \tag{5}$$

When $M=M_0$ at $t=0$,

$$M^{1/3}=M_0^{1/3}-\frac{k}{3}n^{1/3}t \tag{6}$$

If the particles are dissolved completely, namely $M=0$. them time t becomes τ,

$$\tau=\frac{3}{k}n^{-1/3}M_0^{1/3}=b\cdot r_0,\quad b=\frac{3}{k}\left(\frac{4}{3}\pi\rho\right)^{1/3} \tag{7}$$

From (6)
$$M=n\frac{k^3}{27}(\tau-t)^3.$$

$$\therefore\quad -\frac{d^2M}{dt^2}=n\frac{2}{9}k^3(\tau-t)$$

The relation between the variation of reaction velocity with time $-\frac{d^2M}{dt^2}$ and the time t is linear, and the intersection of the line to time axis τ is propotional to the radius r_0 of particles and the inclination particle number n. In the mixed system of various kinds of particle radii, a curve composed of the sum of the straight lines above-mentioned which correspond to each particle size is obtained. From the analysis of the curve similar to sedimentation method, the distribution curve of particle size is obtained.

For the measurement of the reaction velocity, we used the method of thermal analysis which is studied in our laboratory. (This report **17** (1949) 31, Rev. Phy. Chem. Japan. **11** (1937) 439, 13 (1939) 14~**20** (1946) 35). Furthermore was determine the dissolving reaction of $CaCO_3$ 1 gram in 8.3 Mol acetic acid (Buffer solution $0.03MC_6H_8O_7 \cdot H_2O$, 0.1M Na_2HPO_4 $12H_2O$) 100c.c.. For comparison, 6 kinds of $CaCO_3$ ($0.04\mu \sim 50\mu$ in dia.) were also examined by other methods, such as electron microscope, sedimentation method, absorption method, microscope and sieving method and our method, was found very accurate.

19. Studies on the Reactions of Hydrogenation by the Method of Thermal Analysis.

Eiji Suito and *Hiroshi Aida*.

The hydrogenation of fatty acids has deen studied by many investigators since 1897, but there exist only few reports on the kinetics and the heat of the reaction. So we studied kinetically the hydrogenation of oleic asid as an example of the simplest fatty acid by the method of thermal analysis of reaction velocity in liquid phase. (This report, **17** (1949) 31, Rev. Phy. Chem. Japan **11**, (1937) 439, **13** (1939) 24, **20** (1946) 35) In the reaction vessel (a Dewar vessel) immersed in thermostatt (oil bath), preheated hydrogen gas was passed into the oleic acid mixed with Raney catalysts, and the rise of temperature was recorded with time. The temperature of the reaction was 80°C, 100°C and 120°C, respectively, oleic acid 29.9 or 49.6g, catalysts 0.3~1.2g, flow rate of hydrogen 0.2, 0.4 and 0.6 l/min. and the reaction time 60 min.. It was found that the hydrogenation of oleic acid was the first order reaction and the velocity constants were small. Also the rate of reaction was proportional to the quantity of catalysts and the flow rate of hydrogen.

So

$$\frac{dx}{dt} = k \cdot [\text{quantity of catalysts}] \times [\text{flow rate of hydrogen}] \times (\text{concentration of oleic acid})$$

And the value of activation energy was 8.3 Kcal, calculated from Arrhenius equation. The relation between the heat quantity emitted in a given time and the difference of the iodine value of oleic acid in beginning and at the end of reaction is linear and from this the heat of hydrogenation of oleic acid was evaluated as 37.2 Kcal/mol as the average value of 15 experiments.

As mentioned above we obtained the good results in application of the thermal analysis to the high temperature reaction in the liquid phase.